Supervisory Controller for PV and Storage Microgrids

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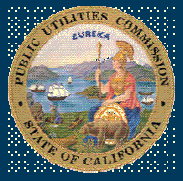
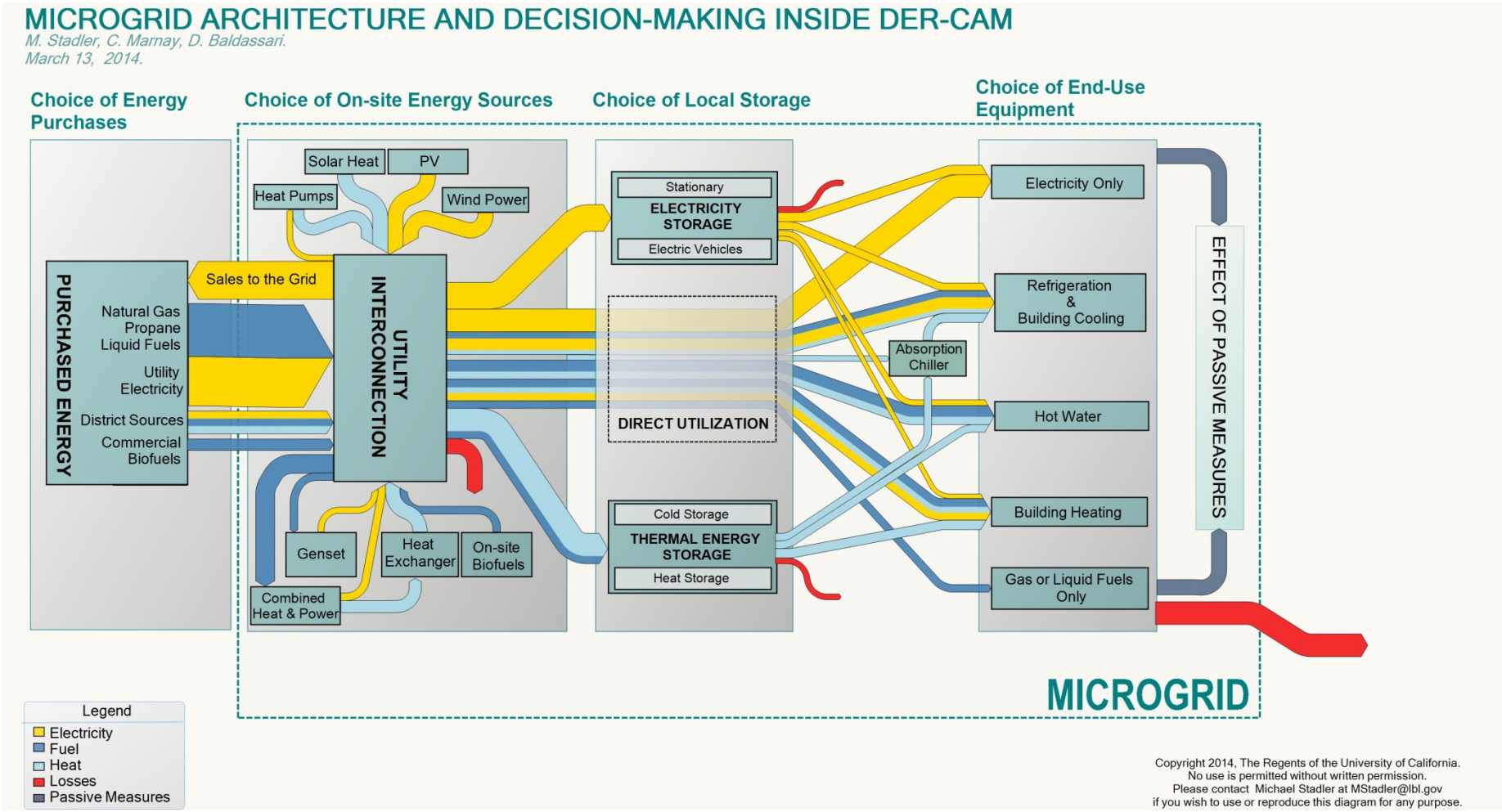
Michael Stadler, Sankar Narayanan

Team: C. Marnay, C. Milan, D. Baldassari, G. Cardoso, J. Eto, J. Tjaeder, M. Stadler, N. DeForest, S. Mashayekh, S. Narayanan, S. Wang, T. Brandt

mstadler@lbl.gov, sankar@tri-technic.com
http://building-microgrid.lbl.gov
http://www.tri-technic.com/



DER-CAM Concept for Microgrids



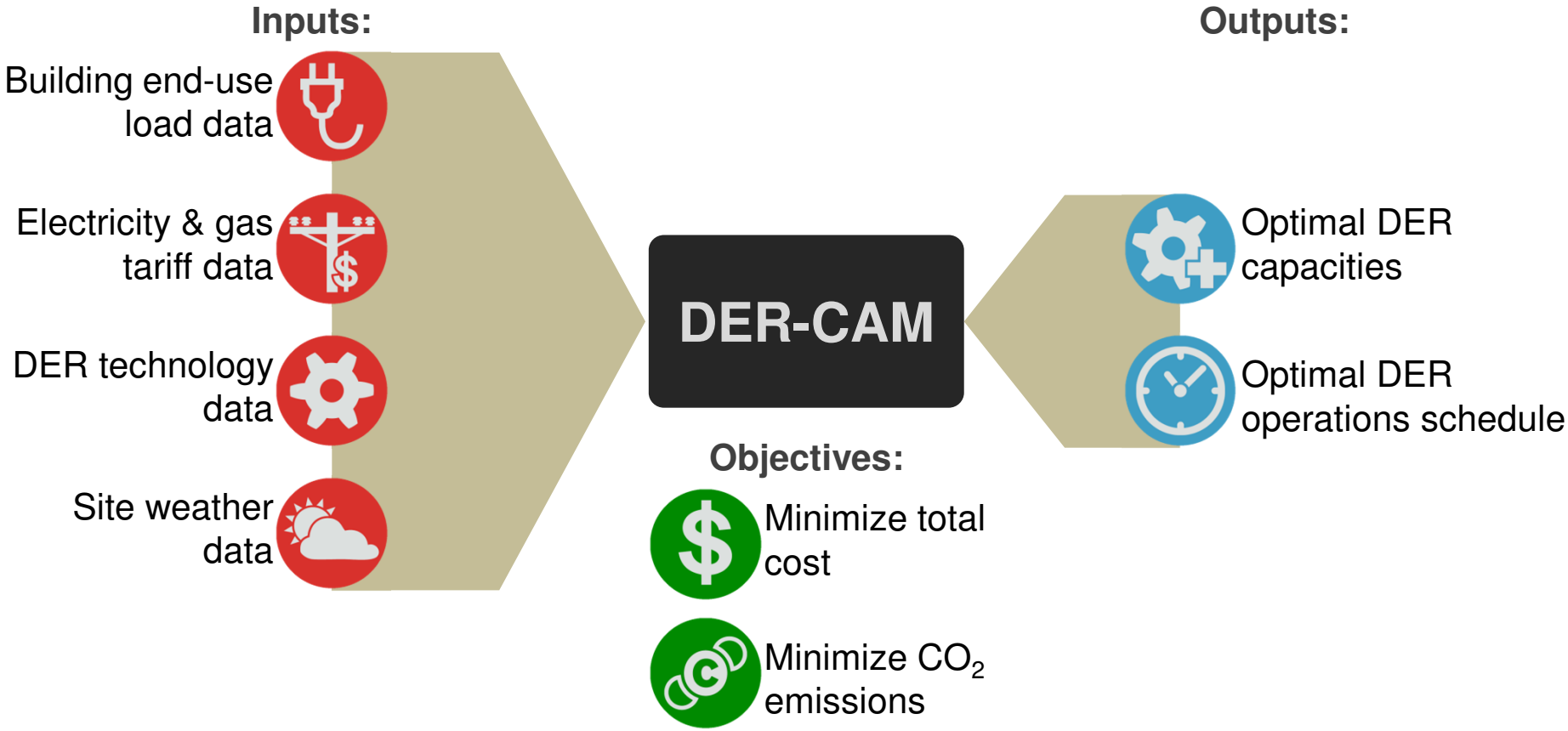
What is DER-CAM?

Distributed Energy Resources Customer Adoption Model (DER-CAM)

- is a deterministic and stochastic Mixed Integer Linear Program (MILP), written in the General Algebraic Modeling System (GAMS®)
- started as a building CHP optimization tool
- supported by the U.S. DOE, OE, DoD, CEC, private industry, and now by CPUC
- two main objective functions:
  - cost minimization
  - CO_2 minimization,
  - and combinations of them

  subject to microgrid/building constraints and energy balance
- produces optimal investment and dispatch results for biogas/diesel/natural gas CHP, fuel cells, ICE, micro-turbines, gas-turbines; PV, solar thermal, hot and cold water storage, batteries, heat pumps, absorption chiller, EV, passive measures as window changes
- free academic version at http://building-microgrid.lbl.gov/projects/distributed-energy-resources-web

DER-CAM



- **Investment & Planning:** determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs
- **Operations:** determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather and tariffs

CPUC Grant for PV and Storage at Fort Hunter Liggett (FHL)

Overview

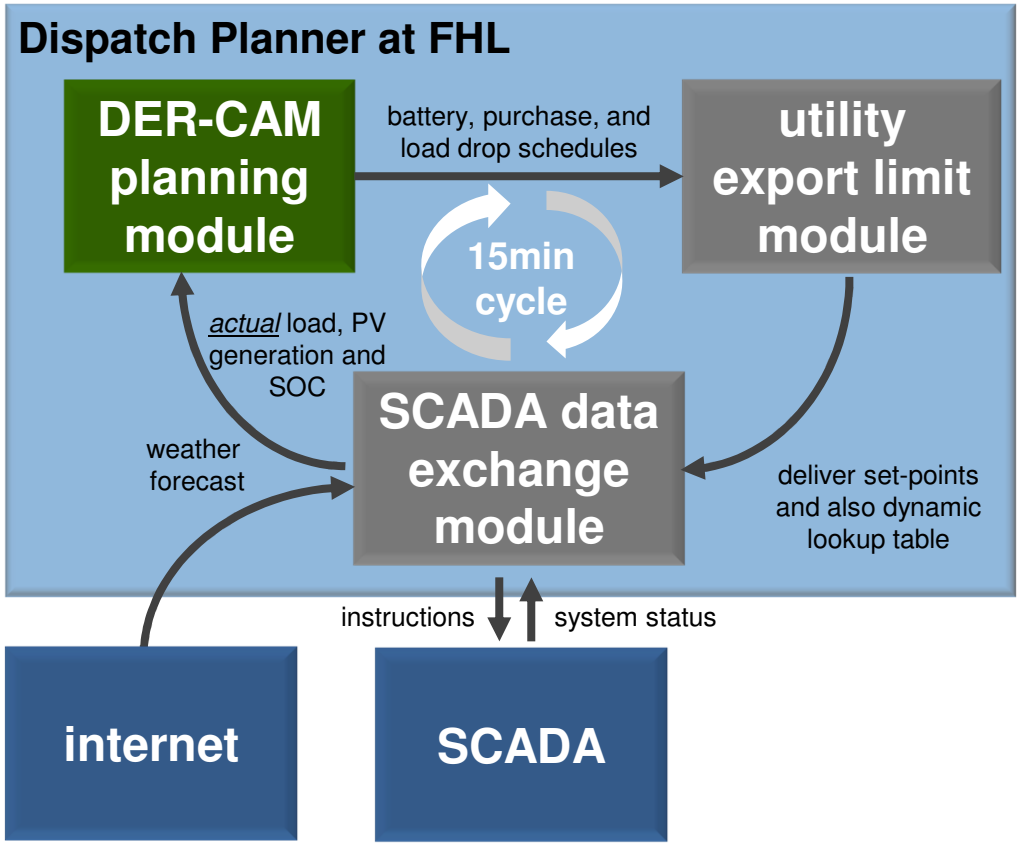
challenge:

- demonstrate the use of day-ahead optimization and real-time control to implement optimal system dispatch
- grid connected operation mode (long term also islanded: not part of CPUC grant)
- distributed systems with multiple on-site energy resources: storage, PV, CHP (CHP not part of CPUC grant), …
- use weather data to forecast PV generation
- use historic data to forecast energy loads
- use **Operations DER-CAM** to produce cost-optimal day-ahead dispatches and feed them to the SCADA system
- emphasis on optimal battery scheduling to ensure PV exports within maximum levels

Overview FHL

- large 2 MW PV and battery system 1 MWh
- in the future 8 MW of PV and full microgrid
- no supervisory controller available

DER-CAM Model for FHL



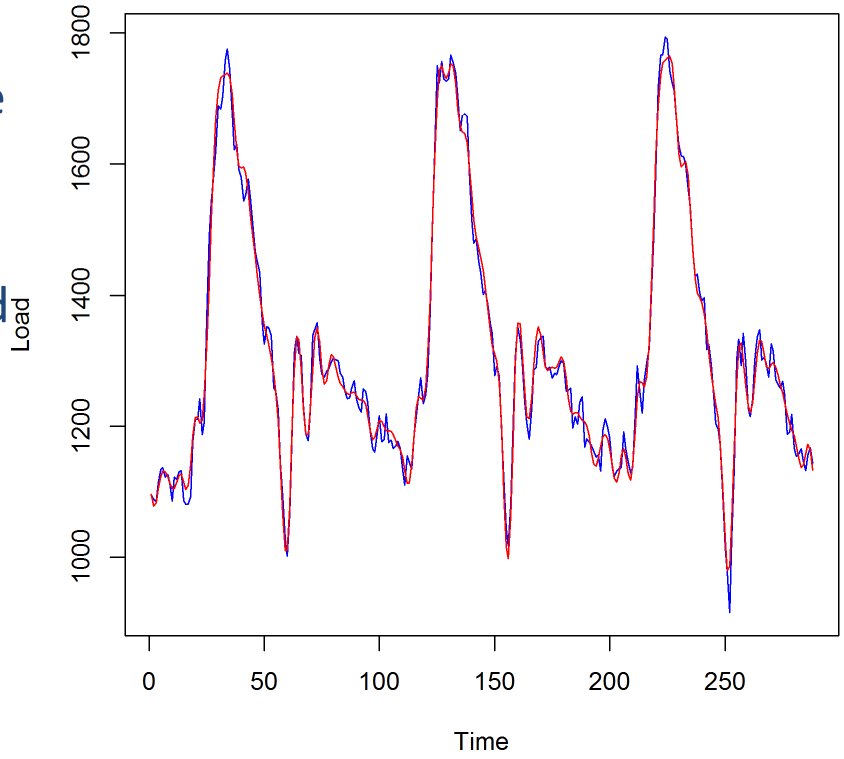
Forecasting Load and PV Generation

For real-time optimization, load and PV generation need to be forecasted for FHL; both factors are driven by *different influences*

- load is driven by base occupancy and shows relatively stable daily patterns; influence of outside temperature appears to be relatively minor
- PV is driven by solar radiation, which depends on the position of the sun and various seasonal patterns; patterns can be very volatile due to clouds
- load data is available in 15-minutes intervals as net load, weather data is available in hourly intervals, PV data varies between 15 minutes and hourly

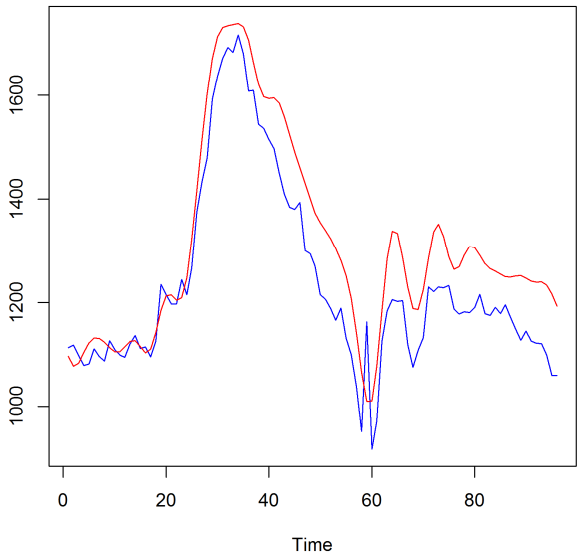
Forecasting Load

- load shows consistent patterns for each day of the week (holidays are similar to Sundays)
- to forecast next Tuesday, the past three Tuesdays are considered and a Fast Fourier Transformation (FFT) is used to extract the most important frequencies
- the resulting curve contains the main pattern without noise



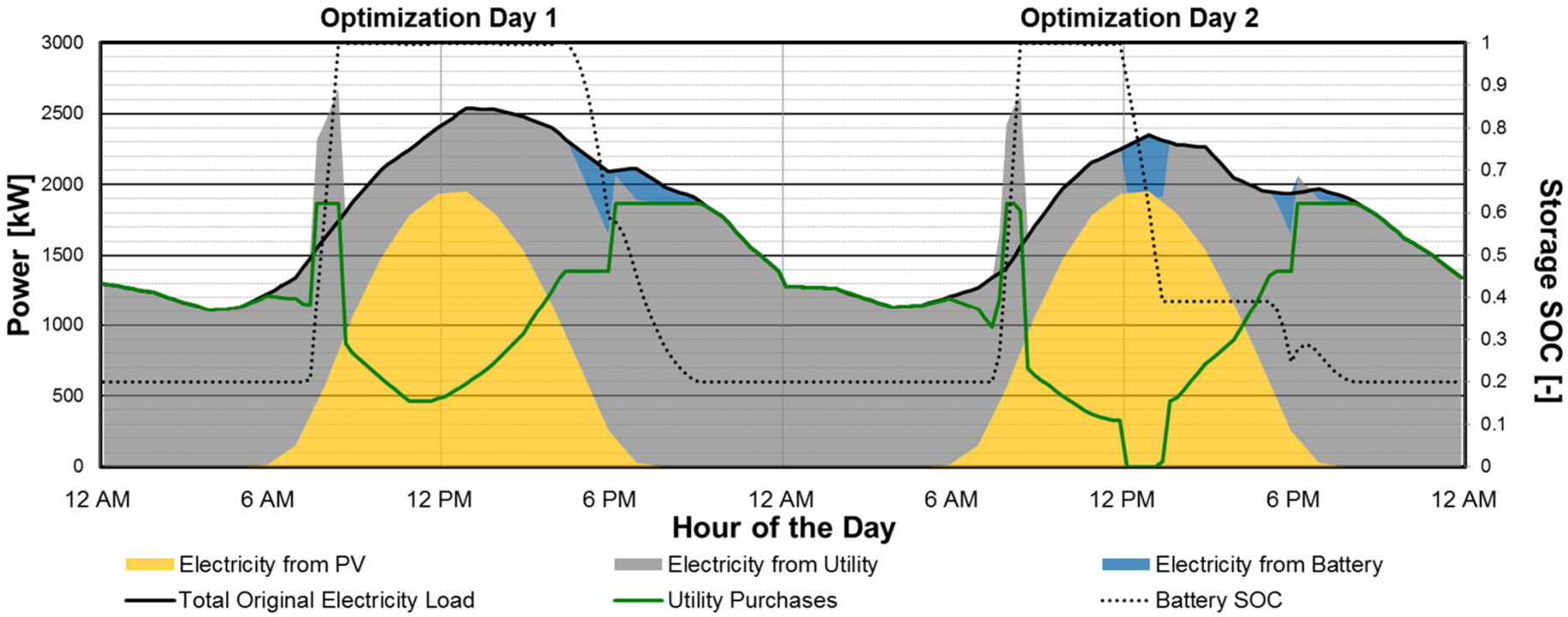
Forecasting Load

average error over a day is around 10%



- 😐 change in base occupancy is only slowly incorporated by FFT
- ☺ forecasted values are multiplied with a parameter ***d*** that starts out at 1 and decreases / increases whenever deviations between forecasted and actual values exceed a certain threshold

DER-CAM Output: Offline Example



End

Thank you!

Questions and comments are very welcome